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sults, but would correspondingly lose in compactness and portability. The apparatus as illustrated has been used in the physical laboratory at Columbia and has proved itself very simple and useful.\*

COLUMBIA COLLEGE, November 18, 1895.

#### MEASUREMENTS OF THE ACCURACY OF RECOLLECTION.

WE know that ordinary observation and recollection are not altogether reliable. We do not credit all the stories that we hear, even though we may not doubt the good faith of the narrators; we see that conflicting evidence is offered in courts of justice when no perjury is intended; we regard as partly mythical records supposed for many centuries to describe historical events. But we do not know how likely it is that a piece of testimony is true, nor how the degree of probability varies under different conditions. If we could learn this by experiment the result would be a contribution to psychology, and would at the same time have certain important practical applications.

\*The above drawing of the local variometer was made by a method which may prove useful to others, and which, so far as I know, is new. It is often desirable to get a perspective line drawing of a rather complicated piece of apparatus without employing a skilled artist, or consuming too much time. To produce the above cut a small photographic negative of the variometer was taken, from which a contact positive was made. The positive was placed in a projection lantern and thrown upon a screen consisting of a piece of drawing paper upon a board, the size of the image being two or three times as large as the cut. The outlines were then traced in with pencil, and one can also shade directly where desired. This sketch was drawn over with india ink and made ready for the photolithographer. The advantage of this method over drawing upon a silver print, which is afterward 'dismissed' is that the drawing and tracing is done upon a larger picture than the final cut, and hence a coarser style may be employed and yet the desired fineness attained in the final reduced cut. Of course a projection lantern of some sort is desirable, but a very simple one will do. The conventional shading in the variometer was put in after the tracing was finished.

W. HALLOCK.

I have tried in various ways to secure a quantitative determination of the reliability of recollection and evidence, and will here report on the answers to some questions asked the junior class in psychology in Columbia College in March, 1893. The questions were answered in all or in part by the fifty-six students present.

Several simple questions were first asked and the students allowed in each case one-half minute to consider and write the answer. They were also requested to assign the confidence which they felt in the correctness of their answer—*a* if quite certain, *b* if tolerably certain, *c* if doubtful, *d* if the answer were a guess.

The first question was 'what was the weather a week ago to-day?' The answers were pretty equally distributed over all kinds of weather which are possible at the beginning of March. Of the 56 answers, 16 may be classed as 'clear,' 12 'rain,' 7 'snow,' 9 'stormy,' 6 cloudy and 6 partly stormy and partly clear.\* It seems that an average man with a moderate time for reflection cannot state much better what the weather was a week ago than what it will be a week hence. Yet this is a question that might naturally be asked in a court of justice. An unscrupulous attorney can discredit the statements of a truthful witness by cunningly selected questions. The jury, or at least the judge, should know how far errors in recollection are normal and how they vary under different conditions.

When asked 'what was the weather two weeks ago?' 20 students answered 'clear,' and 18 'stormy.' The confidence in this case was slight, only two being sure that their answers were correct and 8 having some confidence, while the others were doubtful or did not answer at all.

We ought not, indeed, to conclude from these conflicting answers that no inference as

\*On the day in question it snowed in the morning and cleared in the late afternoon.

to the weather on those days can be drawn. Almost nothing could be inferred from any single answer, but the answers taken together give information of a degree of exactness which may be defined. We can, however, better consider this matter in connection with questions requiring a quantitative answer.

Three questions were asked with a view to learning the ordinary accuracy of observation: "Do chestnut trees or oak trees lose their leaves the earlier in the Autumn?" "Do horses in the field stand with head or tail to the wind?" "In what direction do the seeds of an apple point?" The questions were all answered correctly more often than incorrectly, but only by a moderate majority. Thus 30 students thought that chestnut trees lose their leaves the earlier in the Autumn, and 21 were of the opposite opinion; 34 students thought that horses in the field stand with tails to the wind, and 19 thought they stand facing it. Thus in only about three cases out of five will a college student answer such a question correctly.

Each class of persons would of course have a different index of precision. In the present cases country boys would probably do better, whereas in other directions, as in judging of character, they might not do so well. This opens up an interesting direction for research. Is the ordinary observation of men or women better? of students in classical or scientific courses? etc.

The degree of confidence may be noticed. The students were sure their answers were correct in all 34 times, and in these cases they were in fact correct 27 times. They were somewhat or quite doubtful in all 70 times, and in these cases were correct 37 times, scarcely more than a majority. Their judgment of their own accuracy was therefore of some value, and the degree of confidence can with advantage be taken in

ordinary testimony. But there is great individual difference in this respect. Some observers are nearly always sure that they are right, whereas others whose decision is equally or more likely to be correct are much less confident. In other and more elaborate experiments I have found that when an observer is entirely doubtful, for example as to which of two weights is the heavier, and makes a guess, his guess is more likely to be right than wrong. This opens an opportunity for determining the part played by subconscious inference in the decisions of daily life, as in judging the the character from the face.

As regards the direction in which the seeds in an apple point, 24 answers were 'upward,' or 'toward stem;' 18 'toward center;' 13 'downward,' and 3 'outward.' The reader may be left to decide whether or not he knows in what direction the seeds in fact point, and what information he can obtain from these answers.

Two questions were asked, the answers to which measure the ordinary accuracy of information: "Was Luther or Michel Angelo born the earlier and by how many years?" "In what year did Victor Hugo die?" Michel Angelo was assigned the earlier year in 29 of the 45 answers. The average of the answers placed his birth 12 years before that of Luther, which is nearly the correct value (8 years). The average departure from the correct value was 54 years, which measures a considerable degree of ignorance.

The average assigned the death of Victor Hugo 12 years too early, with an average departure from the true date of 13 years. The median would here give a more correct date, as the average is unduly influenced by a few who assigned a very early date. The extreme values, indeed, betray great ignorance. One student thought Hugo died in 1790, another that he is still alive. One student thought that

Michel Angelo was born 300 years earlier than Luther.

Three questions were asked intended to determine the average accuracy in estimating weight, distance and time. These were the weight of the text-book (James' *Briefer Course in Psychology*) used by the class, the distance between two buildings on the college grounds and the time usually taken by students to walk from the entrance door of the building to the door of the lecture room. The results are shown in the accompanying table, there being given the approximate actual magnitude, the average estimate with the constant error, the average departure of the estimates from the average estimate and from the actual magnitude and the median.

Estimation of	Actual Magnitude.	Average Estimate.	Constant Error.	Average Residual.	Average Error.	Median Estimate.
Ounces,	24	17	- 7	5	8	16
Feet,	310	356	+46	179	162	250
Seconds,	35	66	+31	36	40	60

It thus appears that in these cases there was a marked tendency to under-estimate weight and to over-estimate time. Length was over-estimated, but to a less degree. For the magnitudes used the average vari-

ation was about one-third of the weight and one-half of the distance or time. The actual errors were larger in the case of weight and time, but not in the case of distance. The middle estimate or median value is in all cases smaller than the average. The degree of confidence of the observer does not in these cases seem to measure objective accuracy.

Curves are subjoined showing the distribution of the estimates. The residuals are divided into classes of the size of one-half the theoretical probable errors, and the ordinates represent the percentages of the whole number of observations falling within each class.

The curves approach the bell-shape required by the theory of probabilities, but not very closely. The departures are partly due to the limited number of observations (56 in each case), and the tendency to estimate in round numbers; in estimating time  $\frac{2}{3}$  of the estimates were  $\frac{1}{2}$ , 1 or 2 minutes. But there is a large constant error, and in addition there is an excess of large positive errors which makes the average in all cases larger than the median. This tendency obtains in nearly all variations and measurements and has not received the attention it deserves. The aver-

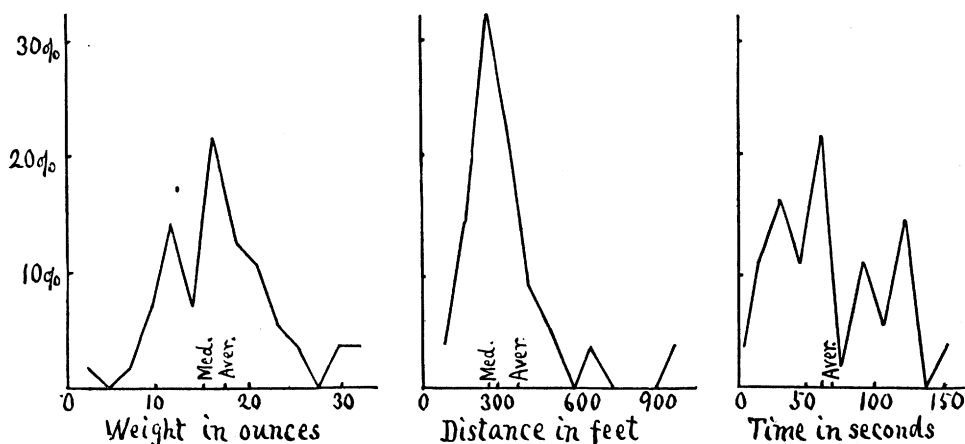


Fig 1. The distribution of errors in estimating weight, distance and time.

age weight of men may be 150 pounds, and there are men weighing 300 pounds, but none weighing 0. In actual measurements it is probable that large positive errors occur more frequently than negative errors of the same size.

When students were asked what was said during the first two minutes of the lecture in the same course given one week before, the accounts were such that the lecturer might prefer not to have them recorded. From the testimony of the students it would appear that two minutes sufficed to cover a large range of psychological

times, but the average estimate of 4,022 had an average variation of 2,669 times. It might be supposed that the number of times was in any case sufficient to impress a tolerably exact recollection of the hall, but the drawings vary to such an extent that any one taken at random would be likely to give an entirely false impression. An examination of the many drawings, however, leaves on the mind a fairly exact idea of the hall, and it would be possible to make a composite drawing which would be found to approach a correct ground plan. Three of the ground plans (supposed to be

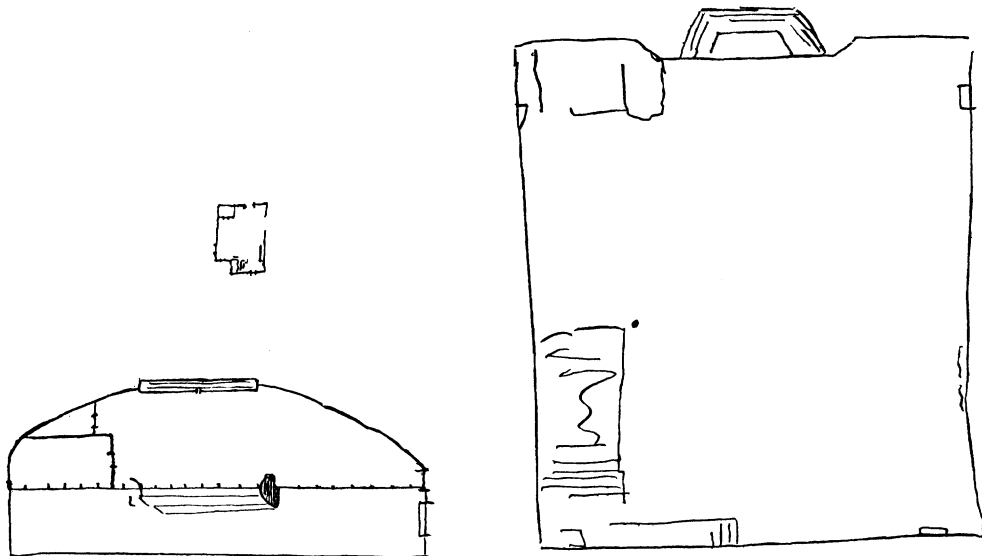


Fig. 2. Ground-plans of a hall drawn from memory (scale 1:96).

and other subjects, and to make many statements of an extraordinary character.

The last task set was to draw in a scale of about  $\frac{1}{4}$  inch to the foot a ground plan of the entrance hall of the building in which the class met, ten minutes being allowed. The students were also asked to state about how many times they had passed through the hall. All the students (with some possible exceptions) had passed through the hall about an equal number of

drawn on the same scale and here reduced about one-half) are subjoined. This is worth the while if only to emphasize the worthlessness of many hundred casual observations as compared with one measurement.

Psychology is continually gaining ground as a natural and even as an exact science, and some progress is made when in any direction the surmise of daily life is superseded by systematized facts and measurements.

It is sometimes said that the useful applications of the material sciences have no parallel in the case of the mental sciences, but I venture to maintain that psychological experiments may have a high degree of practical value. Thus, determinations such as those here described are useful in various ways.

It would be of value to an individual and to those having dealings with him if he could be assigned a definite index of precision. This could be determined early in life, and the effects of environment and methods of education could be determined. It is generally acknowledged that children should be treated as individuals and not as bits of stone to be shaken together until they became marbles, equally round. We consequently need to study methods which will discover individual differences early in the life of the child. Education may properly be devoted to overcoming defects which would interfere with usefulness, but perhaps its more important function is to strengthen qualities which the individual possesses and which may be developed so as to serve his welfare and that of society. From the point of view of science, private benevolence and State aid should be directed less to supplying the cripples with crutches than to supplying the agile with ladders. For this purpose it is evidently important to devise tests which will demonstrate natural aptitudes while the child is very young.

It is especially desirable to devise some objective method to test the fitness of candidates for the civil service. Examinations are of great importance in merely securing some method of appointment other than reward for personal or political services rendered. But the form of examination has often only an artificial connection with the duties of the official. The story is told that in answer to the question "what is the distance of the moon from the earth?"

the candidate replied that he did not know, but that it was not so near that it would interfere with his work in the post office. It is, indeed, a fact that the man who had independently observed (contrary to the testimony of novelists) that the crescent moon does not rise in the evening, or (contrary to the testimony of poets) that a baby does not reach for the moon, would discover mental qualities of greater importance for most work than the man who remembered the number of miles from the earth to the moon. Of course the accuracy of observation would only be one of a number of tests which could be applied. The candidate for post office clerk whose eyesight is good; who can accurately judge of the weight of a letter; who can make many similar movements in succession without becoming fatigued; whose range of perception is large so that he can perceive at a glance the address on an envelope; whose reaction-time is short, so that he can quickly distribute the letters, etc., would probably be a more efficient public servant than one who passed a slightly better examination in grammar and arithmetic. Stress should be laid on the advantages of obtaining quantitative results. In this case the candidates can be arranged in order without any chance of prejudice or mistake on the part of the examiner. The report would show that A has passed a better examination than B, and that the chances are (say) nine to one that this result is correct.

As a last example of the usefulness of measurements of the accuracy of observation and memory I may refer to its application in courts of justice. The probable accuracy of a witness could be measured and his testimony weighted accordingly. A numerical correction could be introduced for lapse of time, average lack of truthfulness, average effect of personal interest, etc. The testimony could be collected in-

dependently,\* and given to experts who could affirm for example that the chances are 19 to 1 that the homicide was committed by the defendant, and 4 to 1 that it was premeditated.

A proper application of measurement and the theory of probabilities to the affairs of daily life would add greatly to intellectual detachment and clearness of view. It would be salutary to have in mind the probable error of the newspaper one is reading. The historian could assign the probable accuracy of each event which he narrates, in the same manner as the physicist assigns a probable error to his measurements. We should know what reliance we can place on the stories we hear, and on our own memory of past events. When the relative probabilities of the various conflicting claims of business, politics and religion are expressed in simple numerical formulas, a great part of the wasted energy of life may be directed to useful ends. It is a long way to travel, but we should advance when and how we can.

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#### CURRENT NOTES ON ANTHROPOLOGY (XIV).

##### LATEST WORDS IN CRANIOLOGY.

IN the 'Monitore Zoologico Italiano,' for May last, Dr. L. Moschen presents an able sketch of the recent conflicts of opinion in craniology, and declares in favor of what he calls 'the natural method.' This is that of Prof. Sergi, already explained in this journal. Moschen shows that the method of Kollmann leads to erroneous results, and that at present no unanimity prevails as to the ethnic significance of skull forms. In this he is unfortunately most correct.

\* The independently formed verdict of three jurors, if concordant, would probably have more validity than the unanimous verdict of twelve jurors in consultation. Questions of such great practical importance as this could be definitely settled by the proper psychological experiments.

Prof. Dr. Busch, of Berlin, has a carefully prepared article in the 'Verhandlungen der Deutschen Odontologischen Gesellschaft' (Bd. VII., Heft. 1), on the cranial forms in different races of men. The paper is marked by close observation and sound judgment. His conclusion is that "the cranial differences of races do not lie in particular measures, nor in the relation of the indices, but in the coincidence of certain peculiarities of the head and face which can scarcely be expressed numerically, but can be shown by accurate pictorial presentations of the different aspects of the skull." This is not far from 'the natural method.'

##### YUCATECAN STUDIES.

THE almost simultaneous appearance of four works, all of exceptional merit, on the archæology of Yucatan cannot fail to excite a wide interest in that country.

First may be named the fifth part of Mr. A. P. Maudslay's contributions to the 'Biologia Centrali-Americana' (London, July, 1895). It is devoted to Chichén Itzá, and contains 24 pages of text and an atlas of 25 plates. The first of these is a very carefully prepared map of Yucatan and Tabasco. Then follow views of the monuments of the site, analyses of the architectural details, and faithful copies of the inscriptions. The singular round tower, called El Caracol, is the subject of especial attention.

Next comes Mr. H. C. Mercer's 'Hill Caves of Yucatan' (Phila., Lippincott & Co.). This gives the results of very painstaking excavations in the caverns of the Sierra de Yucatan. Striking illustrations and an attractive literary style add to the high scientific value of the volume. The author's conclusions may be briefly summed up by the statement that nowhere did he discover traces of an occupation of the soil anterior to the Mayas, or of a civilization